Highlights

Financial Resources for Academic R&D

- **In 1998, an estimated $26.3 billion (in current dollars) was spent for research and development (R&D) at U.S. academic institutions (equivalent to $23.4 billion in constant 1992 dollars).** The Federal Government provided $15.6 billion, the academic institutions $5.0 billion, state and local governments $2.1 billion, industry $1.9 billion, and other sources $1.8 billion.

- **Over the past 45 years (between 1953 and 1998), average annual R&D growth has been stronger for the academic sector than for any other R&D-performing sector.** During this period, academic R&D rose from 0.07 to 0.31 percent of gross domestic product (GDP), a more than fourfold increase.

- **The academic sector performs just under 50 percent of basic research, continuing to be the largest performer of basic research in the United States.** Academic R&D activities have been highly concentrated at the basic research end of the R&D spectrum since the late 1950s. Of estimated 1998 academic R&D expenditures, an estimated 69 percent went for basic research, 24 percent for applied research, and 7 percent for development.

- **The Federal Government continues to provide the majority of funds for academic R&D.** It provided an estimated 59 percent of the funding for R&D performed in academic institutions in 1998, down from its peak of 73 percent in the mid-1960s. Since 1994, non-Federal support has increased more rapidly than Federal support.

- **Three agencies are responsible for over four-fifths of Federal obligations for academic R&D: the National Institutes of Health (NIH—58 percent), the National Science Foundation (NSF—15 percent), and the Department of Defense (DOD—10 percent).** The National Aeronautics and Space Administration (5 percent), the Department of Energy (4 percent), and the Department of Agriculture (3 percent) provide an additional 12 percent of obligations for academic R&D. Federal agencies emphasize different science and engineering (S&E) fields in their funding of academic research, with some, such as NIH, concentrating their funding in one field and others, such as NSF, having more diversified funding patterns.

- **There has been a sizable increase in the number and types of universities and colleges receiving Federal R&D support during the past three decades.** Almost the entire increase occurred among other than research and doctorate-granting institutions, with 604 of these institutions receiving Federal R&D support in 1997, compared to 520 in 1990, 461 in 1980, and 341 in 1971. Although the share of Federal R&D support received by these institutions has increased over this period from 8 to 13 percent (rising from $0.4 billion to $1.5 billion in real terms), the research and doctorate-granting institutions continue to receive close to 90 percent of these funds.

- **After the Federal Government, academic institutions performing R&D provided the second largest share of academic R&D support.** After declining slightly in the early 1990s, the institutional share has been increasing since 1994, reaching an estimated 19 percent in 1998. Some of these funds directed by the institutions to research activities derive originally from Federal and state and local government sources, but—since the funds are not restricted to research, and the universities decide how to use them—they are classified as institutional funds.

- **Industrial R&D support to academic institutions has grown more rapidly** (albeit from a small base) **than support from all other sources during the past three decades.** Industry's share was an estimated 7 percent in 1998, its highest level since 1958. However, industrial support still accounts for one of the smallest shares of academic R&D funding.

- **Over half of academic R&D expenditures have gone to the life sciences during the past three decades.** In 1997, the life sciences accounted for 56 percent of total academic R&D expenditures, 54 percent of Federal academic R&D expenditures, and 58 percent of non-Federal academic R&D expenditures.

- **The distribution of Federal and non-Federal funding of academic R&D varies by field.** In 1997, the Federal Government supported close to 80 percent of academic R&D expenditures in both physics and atmospheric sciences, but only about 30 percent in political science and the agricultural sciences.

- **Total academic science and engineering research space increased by almost 28 percent between 1988 and 1998, up from about 112 million to 143 million net assignable square feet.** When completed, construction projects initiated between 1986 and 1997 are expected to produce over 63 million square feet of new research space, equivalent to about 45 percent of 1998 research space.

- **R&D equipment intensity—the percentage of total annual R&D expenditures from current funds devoted to research equipment—has declined dramatically during the past decade.** After reaching a high of 7 percent in 1986, it declined to 5 percent in 1997.

The Academic Doctoral Science and Engineering Workforce

- **Employment of doctoral scientists and engineers in academia reached a record 232,500 in 1997. Those with full-time faculty appointments were also at an all-time high of 178,400.** But faster growth outside the faculty ranks pushed the full-time faculty share of academic S&E employment to a low of 77 percent.

- **Doctoral employment at major research universities was stable over the decade; robust growth at other universities and colleges accelerated after 1995.**

- **Women accounted for the bulk of net growth in doctoral academic employment.** In 1997, 59,200 women represented one-quarter of employment and 22 percent of those in full-time faculty positions.

- **Doctoral academic minority employment reached 39,100 in 1997, with long-term increases generally in line with rising numbers of Ph.D. degrees earned.** American Indian, Alaskan Native, black, and Hispanic S&E doctorates comprised 6 percent of total employment and of faculty; Asians and Pacific Islanders were 11 percent of total employment.

- **The average age of the doctoral academic science and engineering faculty continues to rise.** Those 55 years or older constituted 13 percent of the total in 1973, 26 percent in 1997.

- **About 29,000 doctorates in the 1994–96 Ph.D. cohorts held academic positions in 1997. Forty-one percent each were in full-time faculty and postdoctoral positions.** In the early 1970s, 76 percent held faculty appointments, while 13 percent held postdoctorates.

- **Fewer than one-third of new science and engineering Ph.D.s hired by the research universities obtained full-time faculty appointments—less than half the percentage of the early 1970s.** In the other institutions, about 60 percent were hired into faculty positions.

- **The tenure-track fraction among young Ph.D.s with faculty appointments—about 75 percent—has remained roughly stable since the early 1970s.**

- **The physical sciences' shares of doctoral academic employment and full-time faculty have declined; the life sciences' shares have increased.** The bulk of the life sciences' growth took place in the nonfaculty segment, especially among postdoctorates.

- **The academic doctoral S&E research workforce—defined as those with research or development as their primary or secondary work responsibility—numbered an estimated 164,700 in 1997.** This represented a very robust 7 percent growth over 1995.

- **In 1997, 39 percent of the doctoral scientists and engineers in academia reported receiving support from the Federal Government.** This percentage has been stable in the 1990s.

- **The balance among S&E Ph.D.s reporting teaching or research as their *primary* activity has shifted toward research, for faculty and nonfaculty alike. But among *recent* Ph.D.s in faculty positions, trends in *primary* activity have reversed direction since the late 1980s:** Teaching rose from 56 percent to 68 percent; research declined from 38 percent to 23 percent.

Financial Support for S&E Graduate Education

- **In 1997, enrollment of full-time S&E graduate students registered a decline for the third consecutive year.** This period of decline followed steady increases in the enrollment of full-time S&E graduate students in every year since 1978.

- **The proportion of full-time graduate students in science and engineering with a research assistantship as their primary mechanism of support increased between 1980 and 1997.** Research assistantships were the primary support mechanism for 67 percent of the students whose primary source of support was from the Federal Government in 1997, compared to 55 percent in 1980. For students whose primary source was non-Federal, research assistantships rose from 20 percent to 29 percent of the total during this period. These shifts occurred primarily in the 1980s, and the relative usage of different types of primary support mechanisms has been fairly stable during the 1990s.

- **The Federal Government plays a larger role as the primary source of support for some support mechanisms than for others.** A majority of traineeships in both private and public institutions (54 percent and 73 percent, respectively) are financed primarily by the Federal Government, as are 60 percent of the research assistantships in private and 46 percent in public institutions.

- **The National Institutes of Health and National Science Foundation are the two Federal agencies that have been the primary source of support for full-time S&E graduate students relying on research assistantships as their primary support mechanism.** Each of these agencies supports about one-quarter of Federal graduate research assistantships. The Department of Defense supports about 15 percent.

- **Research assistantships are more frequently identified as a primary mechanism of support in the physical sciences, the environmental sciences, and engineering than in other disciplines.** Research assistantships comprise more than 50 percent of the primary support mechanisms for graduate students in atmospheric sciences, oceanography, agricultural sciences, chemical engineering, and materials engineering. They account for less than 20 percent in the social sciences, mathematics, and psychology.

Outputs of Scientific and Engineering Research

- **In the mid-1990s, approximately 173,200 scientific and technical articles per year were published by U.S. authors in a set of refereed U.S. journals included in the Science Citation Index (SCI) since 1985.** Seventy-three percent had academic authors; industrial, government, and nonprofit sector authors each contributed 7–8 percent.
- **The number of industrial articles declined by 12 percent, from an annual average of 15,050 in 1988–91 to 13,220 in 1995–97. Industrial article volume in physics fell by 40 percent over the period, but output rose strongly in clinical medicine (19 percent) and biomedical research (12 percent).** This trend signals a shift in publishing activity toward pharmaceutical and other life-sciences-oriented industry segments.
- **Increasingly, scientific collaboration within the United States involves scientists and engineers from different employment sectors. In 1997, 30 percent of all academic papers involved such cross-sectoral collaboration.** Other sectors' collaboration rates were higher: 65 percent for industrial papers and 68 percent for those from the government and nonprofit sectors.
- **Much of the growth in U.S. coauthorship reflects increases in international collaboration.** By the mid-1990s, nearly one of every five U.S. articles had one or more international coauthors, up from 12 percent earlier in the decade.
- **Globally, five nations produced more than 60 percent of the articles in the SCI set of journals:** the United States (34 percent), Japan (9 percent), the United Kingdom (8 percent), Germany (7 percent), and France (5 percent). No other country's output reached 5 percent of the total.
- **The development or strengthening of national scientific capabilities in several world regions resulted in a continuation of a long-term decline in the U.S. share of total article output.** Shares of Western European countries as a group and Asia increased. The number of U.S. articles declined by 4 percent from its high earlier in the decade, while those of Western Europe and Asia rose by 18 and 31 percent, respectively.
- **Countries' science portfolios, as reflected in their published output, show some striking differences.** In some, like the United States, United Kingdom, and many smaller European states, the bulk of the articles falls in the life sciences. In others, notably many Central and Eastern European and Asian countries, the share of articles in the physical sciences and engineering is higher.
- **The increasingly global nature of science is reflected in growing scientific collaboration. In 1997, half of the articles in a set of key world journals covered by the SCI had multiple authors; 30 percent of these coauthored articles involved international collaboration, compared to 23 percent a decade earlier.** This trend affected most nations and fields.
- **The international nature of science is further underscored by patterns of citation. Averaged across all nations, about 59 percent of all citations were to nondomestic articles, up from 53 percent early in the decade.** Citations to U.S. articles nearly always exceeded the volume of citations to the domestic literature.
- **Two trends characterize the position of the United States in international collaboration. For most nations with strong international coauthorships, the number of articles with U.S. coauthors rose.** But many nations broadened the reach of their international collaborations, causing a diminution of the U.S. share of the world's internationally coauthored articles.
- **The linkage between research and perceived economic utility is getting tighter. The percentage of U.S. patents citing scientific and technical articles as "prior art" increased strongly, from 11 percent of all patents in 1985 to 23 percent in 1995. The number of articles cited on these patents grew explosively from 8,600 in 1987 to 108,300 in 1998.** This trend was rooted in the extremely rapid rise of citations to biomedical research and clinical medicine, reflecting perceptions of the life sciences' economic potential and related patenting trends. However, it was not limited to these fields.
- **Academic institutions are seeking to realize financial benefits from their research results. The number of academic patents has risen thirteenfold since the early 1970s.** The 3,151 patents awarded in 1998 represented about 5 percent of U.S.-owned patents, up from 0.5 percent in the earlier period.
- **University patents in the three largest academic technology classes—all with presumed biomedical applicability—constituted 41 percent of all academic patents in 1998.** Overall, academic patents are concentrated in far fewer technology areas than are industrial patents, and are growing more so.
- **University gross income from patenting and licenses reached $483 million in 1997.** Half or more of total royalties were directly related to the life sciences.
- **The number of startups and of licenses and options granted increased strongly.** Forty-one percent of new licenses and options went to large firms, 48 percent to small existing companies, and 11 percent to startups.